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TRANSLATION

DEVELOPMENT OF OPERATIONAL AND STRATEGIC ROCKETS IN THE UNITED STATES

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DEVELOPMENT OF OPERATIONAL AND STRATEGIC ROCKETS IN THE UNITED STATES

Colonel I. Zheltikov

History of development of controlled rockets is not yet half a century old. In the period preceding the Second World War, rocket technology had not emerged from the experimental stage. Only in 1944 the German-Fascist Command started its first bombardment on London and other cities by means of long-range rockets. Imperfection of construction and a series of malfunctions at launching and in flight of V-1 and V-2 rockets led to low effectiveness of their action. The goals set by the Hitlerite Command were not attained. In spite of this, the fact itself of combat use of long-range controlled rockets signified the largest advance in military matters.

After the war the development of rockets made rapid strides. In the capitalistic world United States of America reached the greatest successes in their development and production. At first this was promoted by the fact that Americans at the end of the war seized a large quantity of all possible German rockets, launching and technological equipment, technical documentation,and hundreds of German specialists on rocket arming, headed by the chief designer of the V-2 von Braun.

The V-2 rocket seized by American troops in fascist Germany was subjected to manifold checks and study. Effectuation of experimental launchings of rockets was

awarded to the firm "General Electric."

Considerable difficulties were met in the preparation of the launching of rockets. German specialists came to the rescue. A representative of the General Electric Company, Charles F. Green, wrote: "Valuable help was obtained from German scientists, engineers, technicians and staff, preparing parts of rockets. Their experience and knowledge of these matters, obtained during the overseeing of industrial production and launchings of many hundreds of V-2s, were given to the American staff as fast as working conditions permitted. Their cooperation was fruitful and allowed execution of the program of works on the initial stage for many months"*.

American strategists then already cherished the hope of joining the rocket with the nuclear charge. For that time this was not a simple matter. The V-2 rocket, as is known, could carry a payload in weight around 1 t, and the first American atomic bombs weighed several tons each. Therefore, one of the problems of investigations was the determining of the possiblity of increasing weight of the warhead of the rocket.

During tests of V-2 the payload gradually, i.e., the weight of the combat unit was increased. Of the total quantity of released rockets 71 percent were rockets with a load exceeding the norm, besides this the increase grew from year to year. Thus, for example, during launchings of rockets in 1946 Americans managed to increase the payload only by 68 kg, in 1947 — by 182 kg, in 1948 — by 239 kg, and in 1949 — by 470 kilogram. However, the payload weight of one and a half tons still did not satisfy the American specialists, and particularly their military leaders. Thus they came to a conclusion of the necessity to develop and to build more powerful rockets, which could carry charges of great destructive force. The scope of scientific research and experimental design operations was significantly expanded.

*Rocket investigations of the upper atmosphere, Vol. 1, Moscow, Gosinoizdat, 1957, page 46.

By 1949 main directions were determined in the creation of various types of rockets class "ground-to-ground". The Defense Department decided that they would develop along two basic lines: as winged (winged missile) and as ballistic missiles.

Technical specialists of the fleet considered that the best rocket armament for ships would be the winged rockets. Their main positive side as compared with ballistic rockets was considerably smaller in weight at the same flying ranges. The insignificant speeds and low ceilings characterising the flight of winged rockets did not evoke any particular alarm, since the means of antiaircraft defense at that time still had not ensured reliable combatting of winged missles.

The Air Force Command also required winged rockets. Because winged missiles can be delivered faster for armament, their cost is less; they are simpler in their construction and operation as compared with ballistic rockets. This form of rocket technology was closer to the usual aircraft and the Air Force personnel would have no problem mastering it.

Despite the desires of the leaders of the Naval and Air Forces, Army specialists, who considered the possiblity of development of means of antiaircraft defense, preferred to create ballistic rockets.

Striving for rocket rearmament, all branches of the Armed Forces urgently developed technical tactical assignments. In a short period many contracts were concluded with the monopolies for the creation of various rocket systems. To the fulfillment of these contracts were summoned tens of firms and hundreds of industrial enterprises.

In 1948 one of the first winged rocket, "Loon" was developed for the Navy fleet -- this was a copy of the German rocket V-1 witn small changes. It was designed for attack on important shore objects and could be launched from ship as well as from shore. Experiments were conducted by launching this rocket also from surfaced submarines. The flying range of the rocket "Loon" was close to 320 km. In spite of the use of combined system of control in flight, including an autonomous system

and a system of remote control, the accuracy of the rocket was far from satisfactory. Therefore its purpose was modified. It was used later as a flying target for adjustment of antiaircraft artillery fire.

By 1949 for the Air Force the winged rocket "Matador" was developed, based on an original aircraft type configuration, with the best technical and tactical characteristics. For surface ships and submarines by 1951 the firm "Chance-Vought" developed the winged missile "Regulus".

The first army ballistic combat rockets developed were systems under nomenclature "Hermes" and "Corporal". Their experimental samples were investigated in 1951. "Hermes" which was developed on the basis of the German rocket "Wasser Fall" had a remote control system and attained ranges of 80 km, but like "Loon", it was not accepted for armament. The best characteristics had the rocket "Corporal", being one of the first to enter into the rocket-nuclear weapon arsenal of the United States. Developed and ordered by industry were other types of ballistic rockets, for example the "Redstone", which was a modification of the V-2.

It could carry a nuclear charge and was designed for the support of land troops in carrying out both offensive and defense operations, for attack on strong and important concentrations of the enemy troops and materiel located in the depth of tactical zones, and also for attack on major objectives in operational centers. Rocket engine "Redstone", working on bipropellant — alcohol and liquid oxygen, developed a thrust of 33.75 t and ensured the flight of the rocket over ranges up to 320 km with an initial weight of over 18 t. "Matador" and "Redstone" were launched from mobile land launchers. In spite of the fact that the work on these rocket systems was not completed by 1953, the leaders of the Defense Departments rushed to include them in the nuclear rocket arsenals which were necessary for them to use for political purposes from the "position of strength".

The nine-year period between 1945 to 1954 appeared to be the first stage in development of rocket weapons in the United States, whose characteristic features

were: the development of scientific research, experimental, design, and industrial base for further development in the area of combat rocket technology operations. Regarding the obtained types of rocket weapons with liquid-propellant rocket engines, their limited flying ranges and far from accurate systems of control did not satisfy the military leadership. Military leaders of the United States required continually greater flying range of rockets. For launching distance they took the distance Washington -- Moscow, constituting nearly 8000 km. This was embodied in the period 1954--1958 in the order for the development of intercontinental rocket systems. On 6 March 1955 the Air Force Chief of Staff, General Twining stated that the development of intercontinental rockets was the first priority problem in the program of the Air Force and the pace of operations in the development of the rocket systems "Navaho", "Snark" and "Atlas" would be accelerated.*

For leadership in the development of strategic rockets in the Air Force, already in 1950 was established a main administration for scientific investigations and development of rocket weapons. Firms obtained orders for the development of long-range rockets. The firm "Northrup" was developing preparatory operations in the development of the intercontinental winged rocket "Snark", and the firm "Convair" -- the intercontinental ballistic rocket "Atlas". By 1955 many firms already were in operation on the development of strategic rocket weapons. Specialists and firms occupied with the design and production of rocket weapons, strove to take into account the failures of the first experiments. Especially with the first intercontinental rocket "Navaho", tests of whose separate elements were started in 1952, and showed the need for significant reworking.

From January 1956 to July 1957 the winged rocket "Snark" was tested on the launch pad. After that it started into lot production, in spite of the fact that during these tests were many failures in the work of the propulsion and the control ~~systems~~.

On 1 June 1957 from Cape Canaveral for the first time was launched the rocket

*"Missiles and Rockets" No. 4, 1960.

"Atlas". But soon after blast off it was blown up, due to the failure of one of the motors of the first stage. During the first successful launching on 17 December of the same year the rocket travelled 500 miles. Out of 12 "Atlas" rockets intended for tests (experimental series), seven met with accidents. And only on 28 November 1958 was there realized a launching of an "Atlas" which travelled 6325 miles. This was indeed a successful launching, although the rocket did impact 30 miles from the point of aiming.

Together with these types, development of rocket systems of medium range (2-3 thousand km) for the defense of several bases, which were located in foreign territories around the Soviet Union.

Great expectations were held for the rocket "Thor" whose development was started in 1955. Its first experimental launching took place in October 1957. Adjustment of the "Thor" rocket in comparatively a short period was attained due to the use of ready units of other rockets, in particular the "Atlas". After a certain amount of reworking the Department of Defense put the "Thor" into lot production. At the same time with the rocket "Thor" was developed and was tested rocket "Jupiter" of intermediate operational range.

Frequently, the Army, Navy and Air Force were simultaneously occupied with the development of the same technical-tactics data type rockets. Thus, it was November 1956 until the Secretary of Defense of the United States made a decision on the development and introduction of rocket weapons short range by the Army and Navy Air Fleet, and intermediate range and intercontinental rockets by the Air Force. Exceptions were the three rockets "Thor" "Jupiter", and "Polaris", which because of urgency were developed as before, simultaneously by the Air Force, Army and Navy.

From year to year appropriations for development of rocket weapons launching equipment and the development of rocket proving grounds were increased.

American Proving Grounds White Sands, located on a sparsely populated desert

site, in New Mexico and Texas, and extending 200 km from north to south and 65 km from east to west was found too small and insufficiently equipped for tests of long-range rockets. It was possible to conduct tests of only tactical and certain operational tactical rockets. In connection with this on the penisula of Florida began development of so-called Atlantic Proving Grounds, whose area is 5850 hectares. Its course approximately 8000 km in length, was outlined through the Atlantic ocean in the direction of the Island of Ascension.

On the route of the proving grounds were located 11 observation stations: one on the sea coast of Florida, the remaining ones on the Bahama Islands and on the West Indies. In the Atlantic Ocean during the period of conducted tests were established special duty vessels with crews for observation of rocket flights.

On the territory of the proving grounds were developed launch facilities for launchings of all possible operational-tactical and strategic rockets -- testing stands, mounting towers, blockhouses, landing strips. The proving grounds serviced tens of aircraft, radio transmitting and receiving mechanisms, telemetric equipment, hangars for storage of rockets, laboratories, a liquid oxygen a factor with a productivity of 75 t per 24 hr, optical and photographic equipment, electric power stations, and even their own port.

Overall cost of the constructions and equipment installed on the proving grounds was estimated at half a billion dollars. A significant part of this sum was the expenditure on the equipment for launching sites on Cape Canaveral. The development and equipment of the proving grounds was a part of the general huge program of development of rocket weapons. 13 June 1950 the Department of Defense assigned proving grounds for branches of Armed Forces. To the Army were assigned the White Sands Proving Ground and near the Air Force base in Alamogordo; U. S. Navy -- Point Mugu (California)* and U.S. Air Force -- Cape Canaveral (Florida).

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*Later it was significantly expanded and renamed Pacific Proving Grounds.

The development, the orders of rocket weapons prove industry and their arming of the Armed Forces absorbed in period 1952--1957 annually 1,263,700,000 dollars. However, U.S. Air Force in rocket armament far excelled the army. For the same period they spent for these goals [illegible] dollars. Such a race of rocket arming for the Air Force was encouraged by certain representatives of the ruling circles of the United States, who expressed their opinion about reducing the role of piloted bombers and the necessity of their replacement by long-range rockets.

A general idea [illegible]t appropriations on the development of rocket weapons in the United States is shown on the following Table (in millions of dollars)*.

(a) Бюджетный год	(b) Баллистические ракеты средней дальности и межконтинентальные	(c) Другие снаряды класса «земля — земля»	(d) Ракеты других классов	(e) Общая сумма ассигнований
1946/47	0 *	20	38	58
1949/50	0 *	65	69	134
1952/53	3	403	760	1158
1955/56	515	387	1368	2270
1957/58	2077	639	2391	5107
1959/60 **	2952	509	3173	6634
1960/61 **	3448	383	3155	6986

KEY: (a) Fiscal year; (b) IRBM's and ICBM's; (c) Other "Surface to Surface" type missiles; (d) Rockets of other types; (e) Total sum appropriated.
*Not counting 2.3 million dollars appropriated to "Convair" Corp. for Project MX-774.
**Tentative data.

From the Table it is clear that the appropriation for the development of rockets in period 1946--1961 was 22,357 million dollars. The expenditures were highly increased on ballistic IRBM's and ICBM's(from 3 million in 1952/53 to 3,448 million dollars in 1960/61).

At the cost of high capital expenditures the United States in the postwar years managed to create large quantity of types of rockets and equipment for their launching, to organise their lot production and to obtain them for arming.

Especially great attention was given to rocket armament in the United States in last five years, when their lag in this respect behind the Soviet Union was revealed.

*Interavia Air Letter No. 4410, 28.1, 1960.

To 1960 the Army alone developed 6 rocket systems, including 3 tactical ("Little John", "Honest John", "La Crosse"), 2 operational ("Corporal", "Redstone") and 1 of strategic ("Jupiter"). All of ~~them~~ were accepted for armament. The IRBM "Jupiter" was transferred for armament of the U.S. Air Force. By 1960 the most powerful rocket media as compared with other branches of the Armed Forces of the United States, were at the disposal of the Air Force. For their armaments were obtained 2 winged ("Matador", "Snark") and 3 ballistic rockets ("Thor", "Jupiter", and "Atlas"). These rocket systems were intended for the solution of most important problems which because of one reason or another could not be carried out by aviation or by other means. For the U.S. Navy, whose appropriations were less for rocket armament, was developed a somewhat modified winged rocket "Regulus". Surface ships and submarines were armed with it. However, the main attention of the U.S. Navy was turned to the development of the rocket system "Polaris", operating on solid fuel.

All ballistic rockets of operational-tactical and strategic designation developed in the United States before 1956 have vertical launchings. Their propulsion system works, as a rule, on a two-component liquid fuel: fuel and oxidizer. They are characterised by enormous per second fuel consumption, in general, comparatively of short operational duration and develop an enormous thrust. A large part of ballistic rockets trajectory travels far above the surface of the globe. American specialists consider that opposition to these forms of rockets by means of anti-aircraft defense is very difficult. In the book "Guided Missiles", issued by the U.S. Air Force, was indicated that "only guided missile (it has in mind ballistic rocket — I. Zh.) can deliver an atomic charge to the outlined targets during absence of supremacy in the air. It can travel past any presently known means of interception, since it possesses great speed. It can hit any target".* Exactly for this reason in the last 8—10 years the leaders of the Defense Department of the United States give preference to ballistic rockets, increasing their production and reducing the orders for winged missiles.

*Guided missiles. Moscow, State Inoisdat, 1960, page 7.

However, already during operations in developing ballistic liquid fuel rockets on liquid fuel their essential shortcomings were revealed. All rocket systems were, as a rule, heavy, and consequently, of low mobility. In their accuracy left much to be desired. And mainly, the rockets were unreliable and required much time on prelaunch preparations. Fuel and oxidizer for liquid-propellant rocket engines must be transported and stored separately, since with mixing they ignite. For fuel storage, transportation and servicing it is necessary to have special tanks and fuelers. Rockets with liquid fuel installations ordinarily are fueled before launching, which is time consuming. As a result total periods of preparation of the rocket for use are increased and combat readiness of rocket units is lowered*.

All these drawbacks originate from the actual construction of rockets: propulsion systems, control systems, and launching equipment.

Striving to increase rocket combat readiness, American specialists in 1959 proposed two methods. One of them -- the search for new liquid fuels, allowing storage of rockets in the fueled state for prolonged periods. Replacement of liquid oxygen by other oxidisers in particular nitrogen tetroxide was considered**. The use of storable liquid fuels allowed to reduce time for launching preparation of intercontinental ballistic rockets and intermediate range rockets***.

However, the preference was given to the alternate method -- development of engines operating on solid fuel. These engines possess many great advantages over the liquid-fuel rocket engines. These include, simplicity of construction and dependability of action: possibility of fueling the rocket ahead of time (and not directly before launching); possibility of introduction of subsequent improvements without basic changes of the initial design; the absence of assembly and repair

*"Missiles and Rockets", No. 9, 1959.

**"Missiles and Rockets", No. 2, 1960.

***Ibid No. 3, 1959.

operations on the launching pad; constant readiness for launching; great value of weight factor of the engine; great potential possibilities of improvement of characteristics of the engines and of the rocket as a whole; the possibility of long term storage of the engine collected (fueled) state; the case of location of rockets on submarines and underground launchers with semiautomatic or automatic maintenance*.

Transition to rockets with motors operating on solid fuel began to be considered in the United States as the most radical way of increasing combat readiness of rocket parts. Practical measures conducted in the last few years in the United States reflect this very direction in development of rocket technology.

Rocket engines operating on solid fuel have an older history than liquid-fuel rocket engines. Solid-propellant rocket engines were widely used by the United States in the Second World War in unguided rockets, launched from multicharge ground launchers and aircraft.

After the Second World War the area of use of solid-fuel engines was expanded significantly. Their wide use began in launching boosters for long-range controlled rockets and as sustainer engines for small rockets with limited flying range and small initial weight. The unguided tactical missiles of the U.S. Army "Little John" and "Honest John" with solid fuel engines, developed in the period 1953—1956, ensure the preparation of the rocket for launching in 20 minutes. Launching of tactical rockets with solid fuel engines is realized from mobile installations with an inclined guide rail. For better stabilization and to increase the firing of the rocket accuracy, "Honest John" and "Little John" revolve slowly in flight relative to the longitudinal axis, owing to auxiliary tangential nozzles and inclined setting of stabilizer planes. Precisely tactical rockets with solid fuel engines were a unique intermediate stage to long-range solid fuel rockets.

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*Ibid No. 8, 1957, "Interavia" No. 22, 1958.

In a comparatively short period (1956--1959) the U.S. Army developed a new operational ballistic rocket, the 'Sergeant, with solid fuel engines; it was designed to replace the comparatively old ballistic rocket "Corporal" -- one of the basic operational rockets. In the new rocket are significantly decreased the dimension and weight while retaining approximately the same range. Solid-fuel rocket engine, installed on "Sergeant", can develop a thrust on the earth to 22,700 kg and with the initial weight of the rocket of 4500 kg to ensure the range of its flight up to 140 kilometers*.

In recent years in the developmental stage in the United States was the operational ballistic rocket "Pershing" also with a solid fuel engine, intended for the replacement of the rocket "Redstone' with liquid-propellant rocket engine.

In 1957 in the United States began the development of the ballistic rocket "Polaris' for the U.S. Navy, and primarily for atomic submarines. Since 1961 the first modification of the rocket "Polaris" A-1 became operational. Its engine, operating on solid fuel, with a thrust over 45000 kg ensures the flying range of the rocket up to 2000 km. at an initial weight of 12,700 kg. The developed modifications of this rocket ("Polaris" A-2 and A-3) are calculated at ranges of, respectively, up to 2700 and 4600 kilometers.

In March 1958 the U.S. Air Force issued a command to start work on the new intercontinental ballistic rocket project "Minuteman" with solid fuel engines. The rocket will be a three stage once its range at a weight of approximately 30 t will be close to 10 thousand km. The booster engine supposedly will have a thrust greater than 67000 kg. In the American press an opinion was voiced on the possibility of building even more powerful solid fuel engines. In the last two years there appeared an assumption of the possibility of wide application in rocket weapons of hybrid rocket engines, operating on solid oxidizer and liquid fuel; on solid fuel, containing part of the required oxidizer, and the remaining oxidizer in liquid form or on solid fuel and liquid oxidizer.

*"Flight", 2. 11. 1961.

In the hybrid rocket the characteristics of vibration and also the sensitivity to impact load and temperature changes are improved. Mixing of fuel becomes less dangerous and is easier; the reliability of the engine is increased. In the hybrid system by adjustment of the oxidiser or fuel flow it is possible to change the thrust force to a large degree. Due to separation of the oxidiser and fuel danger of ignition and explosion is decreased*.

Simultaneously with the improvement of chemical fuel engines in the United States from 1956 scientific research and experimental design operations were conducted on development of rockets with nuclear engine installations with a very high specific thrust. The National Astronautics Administration concluded with firm "Lockheed Missiles and Space" a contract for 180 million dollars, providing for the development and manufacture of 10 experimental "Rift" rockets with nuclear engines. This rocket will be in length over 30 m and in diameter approximately 10 m. It is designed for use as the last (third) stage on the gigantic rocket "Saturn C-5". Its engines for the first two stages will operate on chemical fuels. First test flights are anticipated in 1966--1967**. So far the question of nuclear power installations for interplanetary rockets is in abeyance. In the future these installations could find application in intercontinental ballistic as well as in winged rockets.

Development of a highly effective rocket weapon is inconceivable without a perfect systems of control and guidance of rockets to the target. In the United States of America the course of the Second World War equipment for remote control for aerial bombs and aircraft was developed. Obsolete bombers, loaded with explosives, were used for single-mission bombardment of German cities in 1944 and 1945. However, remote control systems useful for control of aircraft with low speeds and relatively small range, did not ensure proper control even in the first American ballistic rocket models.

*"Chemical and Engineering News" No. 5, 1960.

**"Missiles and Rockets" No. 5, 1962.

During development of rockets with liquid-fuel rocket engines two main systems of control were used: radio-technical and internal. The negative side of radio-technical systems of control is their susceptibility to the influence of radio interference. Internal systems of control are not subject to the influence of radio interference, and hence their great advantage.

In the course of development of guidance and control systems of rockets in the U. S. Armed Forces was conducted great experimental designing, aimed at the increase of accuracy of rocket flights. Measures were taken to make the control system invulnerable to jamming. For this the rockets were equipped chiefly with internal systems of control. Thus, on the majority of American rockets, developed in period from 1950 to 1957 were provided systems of radio-technical control, later the preference was given to internal systems.

Scientific research and design organizations, and also firms of the United States, developing control and guidance systems for several years have allotted much attention to analysis of the relative accuracy and of the operating advantages of various systems of guidance and control of strategic ballistic rockets. In published works it is noted that at present the error in internal (inertial) systems of control exceeds twice the error in radio-technical (radio command) systems. However, considerations are declared that by 1965 the accuracy of inertial systems will be increased twice and brought up to the present accuracy of the radio-technical systems.

In spite of the poor accuracy of internal systems of control, they have an important advantage as the possibility of multiple launching of great quantity of rockets. This is especially important for solid-fuel,long-range rockets which are designed for fast launching.

Simultaneously with the propulsion installations, by control and guidance systems significant attention was given in the United States to the development of launching (launch) equipment. The political and military leadership of the United

States demanded from its technical brain power and industry the development of such launching equipment which would in all cases, ensure the present fulfillment of the problems by rocket armament.

During the development of tactical or operational-tactical rockets it was considered that they have to ensure fast preparation for launching, high firepower of units and the ability to transfer rapidly on the field of battle simultaneously with other troops. That's why Americans still in 1960 were striving to design only mobile systems. The concept of "full mobility" includes: the ability to be transferred on any road conditions and over broken terrain, (and also transfer by air), surmounting water barriers without the use of special means; the possibility of rapid deployment on the launching position, conducting prelaunching inspections and the firing of rockets in several minutes; possibility of change of flight range and the force of explosion of the charge by means of replacement of the motors and the warheads. By affirmation of Americans, the example of a complete mobile system is the rocket "Pershing", whose launching equipment is mounted on several motor vehicles*.

The development of launch equipment for strategic rockets was handled completely differently: initially it was constructed as stationary. By 1956 were proposed requirements for ensuring great combat readiness and maximum protection from nuclear blasts.

Thus was developed the launching equipment for the rocket "Titan", which is completely submerged in underground shafts. For the intercontinental rocket "Minuteman" are anticipated the building of stationary underground reinforced concrete launching sites in the form of wells [silos]. On these launching sites rockets must be in constant combat readiness. For protection from damage to the propulsion systems, the fuel and control systems of rockets for a long period of time (several years) is subjected to hermetic sealing of the launcher wells (shafts).

*"Missiles and Rockets" No. 5, 1959.

Simultaneously with the stationary variant of launching equipment of the rocket "Minuteman" from 1959 was developed a mobile combat launching complex on railroad platforms. However, in 1961 these works were discontinued.

The tendency to disperse and to cover up the strategic nuclear rockets directed the military specialists of the United States to the idea of using submarines as carr. .s of long-range rockets. During recent years oceangoing submarines with atomic power installations are being created on a crash basis, each of which can have on board 16 ballistic rockets of "Polaris" type. The use of submarines as mobile launchers and the possibility of launching rockets from under-water position significantly increases the invulnerability of these means, especially during action in vast Arctic regions.

In recent years in rocket construction the United States is observed a tendency to unify nose cones and nuclear charges, i.e., to make them in such a manner so that the same construction would be useful for various rockets. Thus, for example, the nose cone of MK-4, developed for the "Titan", is planned to be distributed also for the rocket "Atlas". This nose cone is equipped with a warhead of significantly higher power than the cones of the initial construction. Thus occurs an interchangeability of warheads of two intercontinental ballistic rockets. At the same time there appeared a tendency for one type of carrier rocket to have charges of various power, the use of which depends upon the importance and character of the targets. In the press it was noted that in the rocket "Corporal" nuclear charges can be applied in capacity of 10, 20, 50 and 100 kt. This will make it possible to execute a large amount of firing problems.

The ruling circles of USA have not rejected the idea of the possible application of chemical and bacteriological weapons with the help of rockets. In the issued works are considered questions of design of warheads of rockets for delivery to the target of chemical poisoning substances and pathogenic bacteria. It is not out of the question that in certain rockets of various types and assignments can

be applied interchangeable warheads with nuclear, chemical or bacteriological equipment.

Striving to increase the quality of rocket technology, and especially the unification of separate units and assembly, it became necessary to use new, more light, durable and refractory materials. Ceramics and polymers already find wide application in rocket construction. For replacement of metals synthetic materials are used. In the new modification of the rocket "Atlas" the crimped metal coal skirt around the two launching motors was replaced by a skirt of fiberglass which decreases the weight of the rocket and improves its characteristic. In this question certain firms go significantly further. For example, "Studebaker-Packard Corp." and "Amsel Propulsion" proposed to the Defense Department to start a scientific research and experimental and design operations to develop rocket engines, body, nose cone, etc. of plastics.

In the given article there are considered only certain questions of the history of development of long-range rocket weapons in the United States in the postwar period and the basic tendencies of development of American rocket technology. This development is on the road ~~of~~ to improvement of technical-tactical and characteristics of the rocket weapon and the broadening of the scope of the execution of firing problems. The military and political leadership of the United States, depending mostly in a new war on the nuclear rocket weapon, are applying great efforts for the development and creation of "second generation" ballistic rockets with solid-fuel engines, reliable and accurate systems of control, mobile launching equipment and interchangeable warheads.

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